SOME PERFORMANCE CHARACTERISTICS OF THE STANDARD CAST-IRON PEANUT SHELLER

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GLOSSARY

Cast-iron grate. Sheller grate made of cast iron.

Cotyledons. The half-kernels obtained when the two parts of a peanut kernel are separated.

Farmers stock. Peanuts in the shell, as received from the farm.

Feed opening. The opening in the lower part of the surge hopper through which peanuts flow into the sheller.

Grate size. Width of the slots in the sheller grate.

Hull. The outside of the pod, consisting of a thin shell of fibrous material; also referred to as the shell.

Kernel. The seed inside the hull; also referred to as the seed.

Milling quality. A measure of the ability of peanut kernels to resist splitting and skinning during shelling operations. The measure used in this publication is the split-kernel outturn of our pilot shelling plant when using the standard commercial cast-iron sheller and operating the pilot plant to obtain a minimum split-kernel outturn. Low split-kernel outturns indicate good milling quality, and high split-kernel outturns indicate poor milling quality.

Net farmers stocks. Farmers stock peanuts that have been cleaned to remove foreign material and loose shelled kernels (LSK).

Pod. The complete peanut, consisting of kernel(s) enclosed by a hull (shell).

Shell. See *Hull.*

Sheller bar. A steel bar on the shelling cylinder that stirs the peanuts and forces them against the sheller grates.

Shelling cylinder. Cylinder made up of sheller bars supported by bushings on a central drive shaft; the cylinder rotates, forcing peanuts against the sheller grate.

Sheller grate. A casting with slotted openings, a cage formed by a lattice of bars, or a sheet-metal screen with slotted openings, surrounding the shelling cylinder.

Shelling efficiency. The percentage of peanuts shelled in one pass through a sheller, based on the weight of net farmers stock.

Shelling rate. The weight of the peanuts shelled divided by the time required for shelling. The shelling rate equals the throughput (or flow rate) times the shelling efficiency.

Split kernel. A peanut kernel that has been separated into its two cotyledons.

Split-kernel outturn. The percentage of kernels broken in half (into cotyledons) during shelling, based on the weight of net farmers stock.

Stages of shelling. Steps in the peanut-shelling process that shell selected ranges of pod sizes.

Steel T-*bar grates.* Sheller grate consisting of a lattice of thin, tapered steel bars.

Surge hopper. A small bin that directs the flow of peanuts into the sheller.

Type of peanuts. A general classification of peanuts used primarily for

marketing purposes. The four types are runner, Spanish, valencia, and Virginia. Each type has its own commercial varieties. Originally, classification by types was based upon botanical characteristics plus convenient marketing characteristics. However, development of many commercal varieties by infraspecific hybridization has considerably weakened the botanical basis. Some general characterstics of the four different types are as follows:

Runner. Originally from the botanical variety *hypogaea*. Average pod and kernel size is usually intermediate between that of Spanish and Virginia peanuts. Plant growth may range from upright to spreading (but it is constant for any variety). There are usually two seeds and sometimes one seed per pod. Seeds usually have an appreciable fresh dormancy. Edible-grade shelled runners are used primarily in the manufacture of peanut butter and candy.

Spanish. From the botanical variety *vulgaris*. Average pod and kernel size is generally smaller than for other types. Growth is upright, and Spanish typically have two seeds and sometimes one seed per pod. There is very little fresh seed dormancy. Edible-grade shelled peanuts are used mostly in the manufacture of peanut butter, salted nuts, and candy.

Valencia. From the botanical variety *fastigiata*. Average pod and kernel size is generally intermediate between that of Spanish and Virginia. Growth is upright, and valencia has one to (rarely) five seeds per pod. There is very little fresh dormancy. Most valencia peanuts are not shelled but are used by processors of inshell boiled or roasted peanuts.

Virginia. Originally from the botanical variety *hypogaea*. Average pod and kernel size is generally larger than for other types. To be classified as a Virginia type, at least 40 percent (by weight) of the pods must ride a 34/64-inch-wide grading slot. Growth habit may range from upright to spreading (but is constant for any variety). There are two seeds and sometimes one or three seeds per pod. Seeds have an appreciable fresh dormancy. The larger pods are usually removed and used by processors of roasted inshell peanuts. The smaller pods are shelled, and the edible-grade shelled peanuts are used primarily by "salting" processors and candy manufacturers.

Variety. A cultivar having distinct, uniform, and stable characteristics. All peanuts evaluated were from named varieties (cultivars) that had been released for commercial production.

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SOME PERFORMANCE CHARACTERISTICS OF THE STANDARD CAST-IRON PEANUT SHELLER

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ABSTRACT

Effects and interactions of peanut (*Arachis hypogaea*) characteristics, grate design and configuration, surge hopper design, peanut flow, width of sheller bars, cylinder design and speed, and distance between cylinder and grate on the performance of a standard commercial cast-iron peanut sheller were investigated. Results showed that several changes in sheller design and operation, better maintenance of the sheller, and more efficient pre-cleaning of peanuts would greatly lower split-kernel outturn and would raise shelling efficiency and rate.

INTRODUCTION

The present method of shelling peanuts (*Arachis hypogaea*) has been used since shelling was mechanized. Conventional shelling equipment has been designed and developed through trial and error rather than from basic engineering and scientific data. Little has been published about the actual shelling process and the performance characteristics of peanut-shelling equipment. Elliott and Carmichael[2] reported some preliminary shelling data obtained with a small sheller using 15- to 50-pound samples of Spanish peanuts. The data they obtained provided some indication of the peanut properties affecting sheller performance and emphasized the need for further research.

Reed and Coppock[3] reported the effects of some factors on the operation of peanut shellers and the quality of seed produced when shelling Alabama-grown runner peanuts with a small sheller. This work primarily emphasized the need for a feed opening large enough to supply peanuts to the sheller.

Prior research has evaluated the performance of laboratory equipment, giving us useful information. However, this information often is not applicable to the performance of plant-size shelling equipment. Modern harvesting and handling practices, together with the emphasis on high-quality shelled peanuts, have made the peanut industry more aware of the need for information on the performance of plant-size shelling equipment. To compete, owners and operators of peanut-shelling plants must install the best equipment and learn and use the best operating methods and techniques.

This research was performed to obtain information that could be used to improve the operation of the standard cast-iron sheller and to develop and evaluate improvements in the design of the grates, cylinder, and surge hopper.

MATERIALS AND METHODS

Construction of Commercial Shellers

Commercial peanut shellers consist primarily of an open 9- to 10½-inch-diameter shelling cylinder centered inside a sheller grate that is 12 to 14 inches in diameter and 40 to 45 inches long. A surge hopper above the cylinder feeds

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[2] Elliott, T. A., and Carmichael, B. W. 1951. Machinery for cleaning farmers stock peanuts. Ga. Agric. Exp. Stn. Annu. Rep., 44 pp.

[3] Reed, I. F., and Coppock, G. E. 1952. Effects of some factors on the operation of peanut shellers and quality of seed produced. Peanut J. Nut World, 4 pp.

peanuts into the sheller. Presently, there are at least four variations in the design of commercial shellers, each with its own performance characteristics. This report discusses only one of these designs, a sheller with a cast-iron grate. The general design and construction are shown in figures 1 and 2.

The standard sheller grate is made in four sections to allow easy installation on or removal from annular supports in the end plates. The four grate sections enclose more than four-fifths of the 12-inch-diameter circle and leave only a 4-inch-wide feed opening. Each section of the grate has staggered protrusions on the inside surface. These protrusions obstruct the movement of peanuts inside the sheller and provide edges to break open the pods. The slotted openings between the staggered protrusions provide additional edges for breaking the hull as well as openings for removing the peanut kernels, hulls, and small pods.

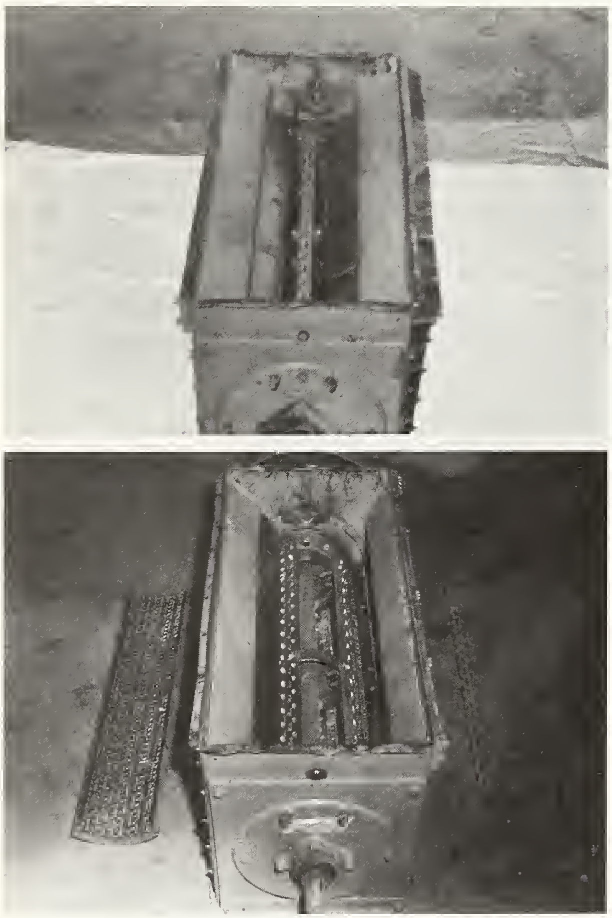

FIGURE 1.—Commercial peanut sheller with cast-iron grate. (*Top*) Sheller assembled. (*Bottom*) Sheller with one grate section and one sheller bar removed.

The shelling cylinder is centered concentrically within the sheller grate. The standard shelling cylinder is open with three equally spaced sheller bars that are supported by hubs installed on the ends and middle of the central shaft. Standard sheller bars are 2-inch- and 4-inch-wide cast-iron bars. On their outside surfaces facing the sheller grate, the bars have numerous staggered protrusions, similar to those on the grate, which provide additional corners or edges for breaking open the pods. These protrusions are to hit and stir the peanuts as the bars move.

The surge hopper is constructed of sheet metal. When full, it maintains a 1.5-foot-high column of peanuts above the feed opening and directs the flow of peanuts into the space enclosed by the grate assembly.

Variables Investigated

The performance of the peanut sheller was determined from its split-kernel outturn, shelling efficiency, and shelling rate. The effects of several variables on sheller performance were investigated. These variables were grouped into eight categories: (1) peanut milling quality; (2) type and variety of peanuts; (3) grate design; (4) grate arrangement, surge hopper design, and methods of directing peanuts into the sheller; (5) width of sheller bars and shelling cylinder design; (6) radial distance between grate and cylinder; (7) grate (slot) size; and (8) cylinder speed.

Pilot Shelling Plant

Tests were conducted with a pilot shelling plant at the National Peanut Research Laboratory, Agricultural Research Service, U.S. Department of Agriculture, Dawson, Ga. This plant has equipment and processes similar to those of commercial shelling plants. The major processing operations of the plant are shown in figure 3, with a more detailed description given in figure 4.

In commercial plants that shell Virginia peanuts, the large pods ("jumbos" and "fancies") are usually removed and routed around the sheller for marketing in the shell. However, in these studies the fancies were not removed, and the Virginia peanuts were shelled in the same manner as the runner and Spanish peanuts.

Commercial cast-iron shellers were used for all four stages of shelling. A full-size (44-inch-

long) commercial sheller was used in the first stage of shelling, a three-quarter size (33-inch-long) sheller for the second stage, a one-half size (22-inch-long) sheller in the third stage, and a one-quarter size (11-inch-long) sheller for the fourth stage of shelling. The pilot-plant performance was dependent primarily upon the first stage because it normally shelled 50 to 95 percent of the peanuts.

The pilot plant was set up to provide a minimum split-kernel outturn for each lot of peanuts. Sheller components and their arrangement were varied only in the first-stage sheller; the other three stages remained unchanged for all

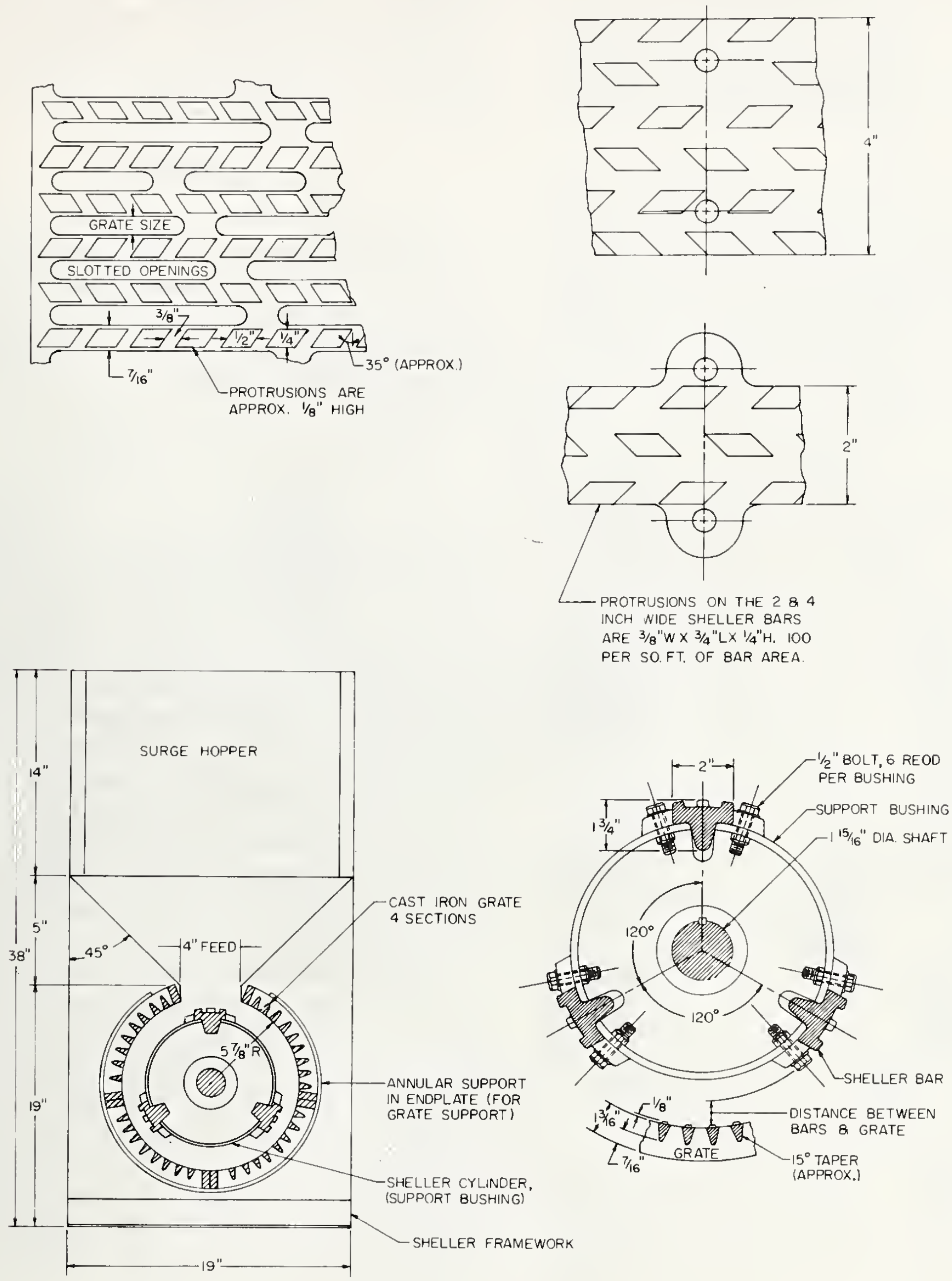

FIGURE 2.—Details of cast-iron peanut sheller. (*Top left*) Shelling surfaces of grate. (*Bottom left*) Sectional view of sheller. (*Top right*) Shelling surfaces of 4-inch-and 2-inch-wide sheller bars. (*Lower right*) Sectional view of cylinder and portion of grate.

shelling of a specific lot of peanuts. Samples were taken underneath the first-stage sheller to determine shelling efficiency and shelling rate.

Peanuts used in the shelling tests were of the three major types (Virginia, Spanish, and runner) obtained in 15- to 60-ton lots from commercial warehouses in the Southeast, the Southwest, and the Virginia-Carolinas producing areas. Usually, each lot included several peanut varieties (mixed storage). Several lots were obtained over a 5-year period to provide data representative of a wide range of conditions.[4] Peanuts of each lot were thoroughly mixed and were normally divided into 750-pound samples for pilot-plant shelling tests.

A statistical design to evaluate all variables and interactions for each lot of peanuts was impractical because of limitations in time, peanuts, and labor. Instead, one or two variables were investigated independently while the remaining were held constant. Average kernel moisture of the peanuts was approximately 7 percent on a wet basis. To minimize the effect of peanut temperature on sheller performance,[5] shelling tests were conducted only when the ambient temperature was above 45° F.

[4] The 1st letter in a lot number identifies the type of peanuts: R=runner, S=Spanish, V=Virginia. The numbers after the 1st letter identify the crop year in which the peanuts were grown. The last 2 letters identify the general location where the peanuts were grown: SE=the Southeast, SW=the Southwest, VC=Virginia-Carolinas area. A number at the end of a lot number indicates that there was more than 1 lot obtained for this location and crop year.

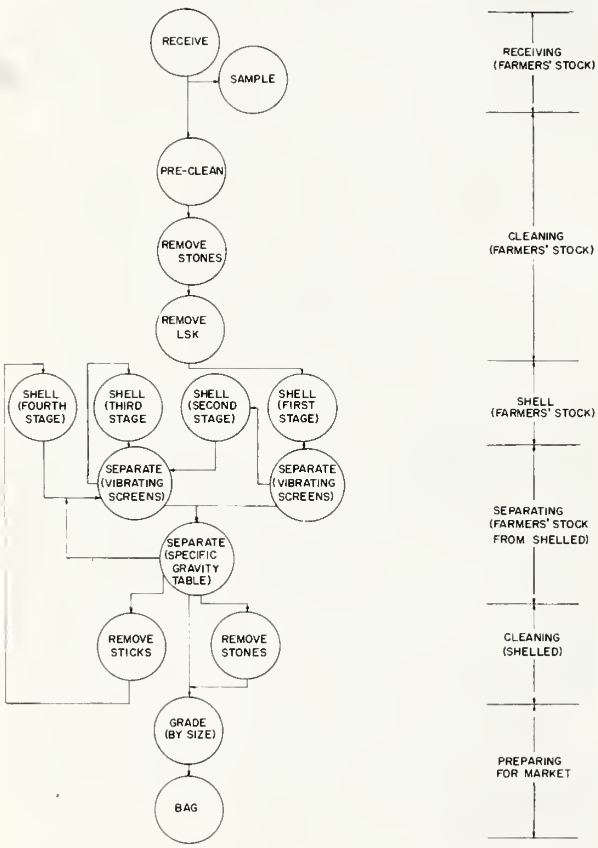

FIGURE 3.—Schematic of major processing operations of the pilot shelling plant.

RESULTS

The data obtained from these studies were analyzed in detail, but the analyses are condensed in this report to present only the average effects and interactions of the variables on sheller performance as they relate to possible improvements in the design and operation of this sheller.

Milling Quality

Milling quality, as measured by split-kernel outturn, and corresponding shelling efficiencies and shelling rates obtained when shelling test lots in a standard cast-iron sheller to obtain a minimum split-kernel outturn are presented in table 1. Milling quality was usually determined mathematically from regression equations of split-kernel outturn versus sheller speed. Based on distribution of split-kernel outturn values for several commercial lots, good milling quality would be indicated by split-kernel outturns of less than 8 percent, average milling quality by outturns of 8 to 12 percent, and poor milling quality by outturns greater than 12 percent.

The milling quality and properties of these peanuts varied considerably, resulting in large variations in sheller performance and in the determination of the best grate (slot) size combinations. The mixing of varieties while in storage, differences in weather and soil during growth, and differences in growing, harvesting, drying, handling, and storage practices undoubtedly contributed to this variability. Shelling rates were usually about twice as high as

[5] McIntosh, F. P., and Davidson, J. I., Jr. 1971. Effect of temperature on shelling Runner- and Spanish-type peanuts. U.S. Dep. Agric., Agric. Res. Serv. [Rep.] ARS 52–65, 4 pp.

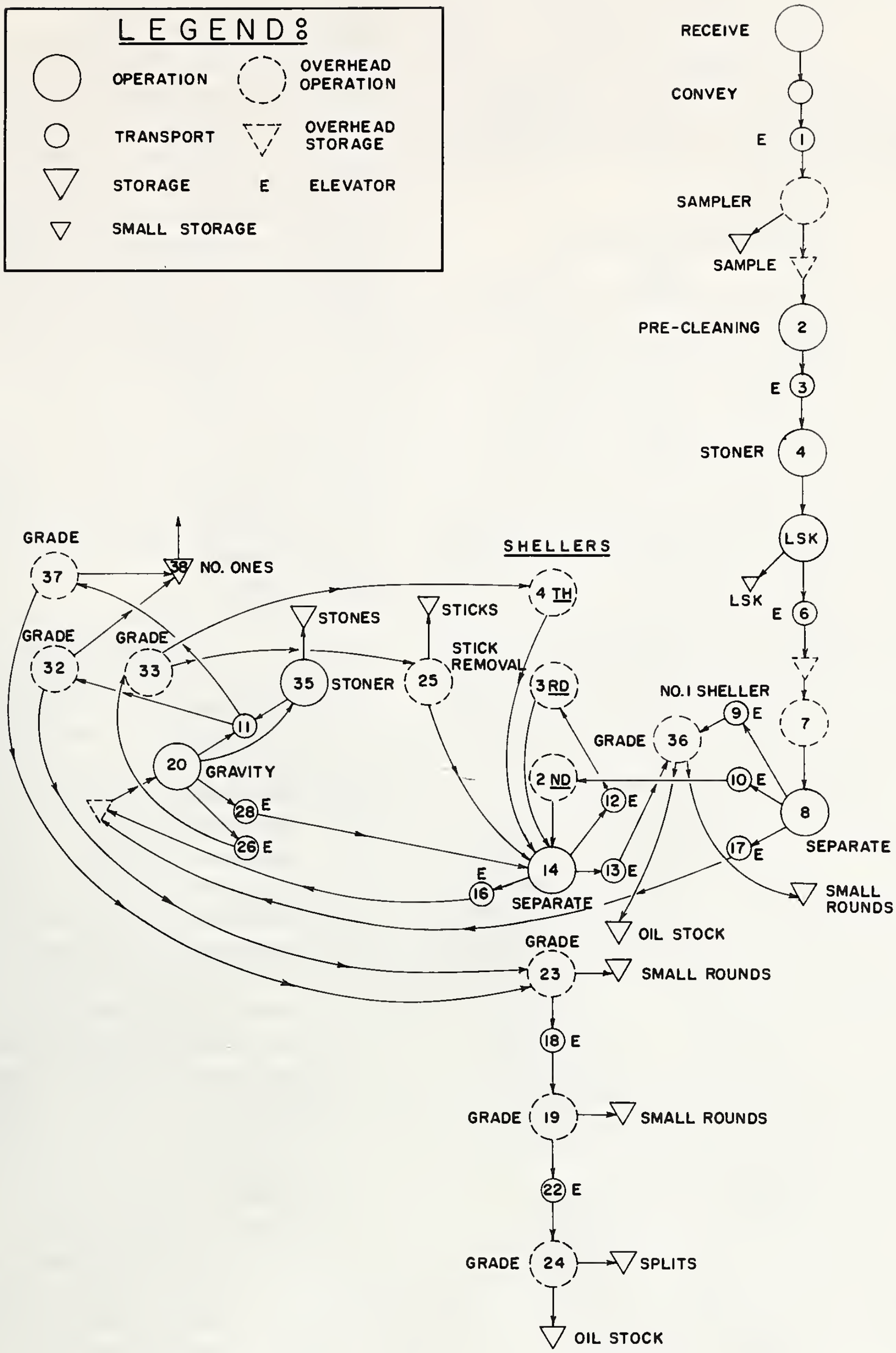

FIGURE 4.—Detailed schematic of processing operations.

obtained in commercial shelling plants, probably because the peanuts going into the sheller were exceptionally clean and because sheller grate and bars were new and were maintained to provide the best possible performance.

There was no correlation between milling

quality and shelling efficiency or shelling rate. It appeared, as in other investigations,[6] that variations in shelling efficiency and rate resulted directly from variations in pod size, shape, and strength rather than from variations in milling quality and in properties directly affecting milling quality.

Peanut Types and Varieties

The size, shape, and strength of peanuts, characteristics of the type and variety, have been found to affect the performance of commercial shellers. When the cast-iron sheller was adjusted to give minimum split-kernel outturn for each lot, there was usually no significant difference in the outturns for the types and mixed varieties tested (table 2). In other studies where varieties were not mixed and the peanuts were grown, harvested, and handled under similar conditions, the split-kernel outturn was significantly affected by differences in varieties. In tests using single varieties, the ranking of varieties according to split-kernel outturn, from lowest to highest, was usually 'Florunner', 'Early Runner', 'Starr', 'Tifspan', 'Spancross', 'Florigiant', and 'Argentine'.

Shelling efficiency of the sheller was significantly higher for the mixed Spanish varieties than for the mixed runner or Virginia varieties. The relatively poor shelling efficiencies for the runner and Virginia varieties were attributed to the larger grate openings needed to prevent excessive splitting of the large, sometimes elliptical, kernels that bring a premium price. In such cases the size of slots in the grate (grate size) was chosen to accommodate the largest kernels. Cast-iron grates with openings large enough to pass the largest kernels allowed many of the smaller pods of varieties that have smaller seeds to pass through the sheller grates without being shelled. In the studies using single varieties, the ranking of varieties from those giving the lowest shelling efficiency to those giving the highest shelling efficiency with the cast-iron sheller usually was 'Starr', 'Early Runner', 'Tifspan', 'Argentine', 'Florigiant', and 'Florunner'.

Differences in varieties usually had a significant effect on the shelling rate when the cast-iron sheller was adjusted for minimum split-kernel outturn. Since the distance between cylinder and grate was approximately the same for all lots, the lots with the largest pods would generally have the highest shelling rates. This is probably why shelling rates were highest for lots containing a large percentage of 'Florigiant' peanuts, a large-podded variety. The studies using spacings between cylinder and grate that were proportional to average pod size indicated that ranking of varieties from those giving the lowest shelling rate to those giving the highest shelling rate was 'Starr', 'Spancross', 'Argentine', 'Florigiant', 'Early Runner', 'Tifspan', and 'Florunner'.

Grate Design

The standard cast-iron grate is designed for heavy-duty operation, is very durable, and gives almost no trouble with minimum maintenance. Protrusions on the inside edges of the grate receive most of the wear; the edges of the slots wear very little. Reinforcing ribs on the back of the grate permit the metal edges of the slots to be thin. The thin wall thickness at the openings permit some of the large irregular-shaped peanuts and foreign material to pass through the openings because the thin wall at the slot allows more mobility of the peanuts and foreign material in orienting their irregular shapes to pass through the slot. Most plant operators using this sheller do not sharpen the protrusions, but use the grate until the edges are worn almost flat. Tests with other kinds of shellers indicate that the shelling rate decreases substantially with increased grate wear. Operators of shelling plants report average shelling rates that are about 20 to 50 percent lower than reported here. Low shelling rates result from use of a worn grate and worn sheller bars and from clogging of sheller and grate by foreign material.

Openings in the cast-iron grate rarely exceed 30 percent of total area because strength becomes inadequate as the space between the openings is decreased. Considerable interest has been shown in the possibility of using a

[6] McIntosh, F. P., and Davidson, J. I., Jr. 1971. Selected physical and shelling properties of Florunner peanuts. U.S. Dep. Agric., Agric. Res. Serv. [Rep.] ARS 52-68, 24 pp. Davidson, J. I., Jr., Hammons, R. O., Dillard. W., and Moss, R. B. 1973. Selected physical, shelling, and germination properties of the new Spanish peanut varieties 'Spancross' and 'Tifspan'. U.S. Dep. Agric., Agric. Res. Serv. [Rep.] ARS-S-24, 11 pp.

TABLE 1.—*Split-kernel outturn, shelling rate, and shelling efficiency when operating standard cast-iron sheller to obtain a minimum split-kernel outturn*[1]

Lot number[2]	Split-kernel outturn, full sheller (pct)	Shelling efficiency, 1st-stage sheller[3] (pct)	Shelling rate, 1st-stage sheller[4] (lb/hour)	Width of sheller bars inches	Slot size (1/64-inch) 1st stage	2d stage	3d stage	4th stage	Cylinder speed (r/min)
R1965SE	8.4	...	...	4	26	23	20.5	15	195
R1966SE	10.5	49.8	4,240	2	28	24	20.5	15	170
R1967SE	12.8	56.5	2,017	4	26	24	20.5	17	165
R1970SE	9.7	75.0	2,896	4	26	23	20.5	15	205
S1965SW	3.1	...	...	4	24	22	19	15	170
S1966SW	3.6	69.3	3,220	4	24	22	19	15	205
S1966SE	10.5	75.8	3,313	4	24	22	20.5	15	170
S1967SW	9.5	81.7	4,367	2	24	22	20.5	15	165
S1970SE	17.2	92.5	5,212	2	22	20.5	19	15	205
S1971SW	17.6	91.6	3,182	2	22	20.5	19	15	205
V1966VC1	10.1	89.0	3,838	4	28	26	24	20.5	165
V1967SE1	12.1	56.8	4,587	2	36	28	26	19	165

[1] Standard grate, cylinder, and surge hopper designs and standard distance (0.75 inch) between grate and sheller bars were used for all runs, except the distance between grates and sheller bars for lot S1971SW was approximately 1⅛ inches.

[2] The 1st letter in the lot number identifies the type of peanuts: R = runner, S = Spanish, V = Virginia. The numbers after the 1st letter identify the crop year in which the peanuts were grown. The last 2 letters identify the general location where the peanuts were grown: SE = the Southeast, SW = the Southwest, VC = Virginia-Carolina area). A number at the end of a lot number indicates that there was more than 1 lot obtained for this location and crop year.

[3] Correlation coefficient between milling quality (split-kernel outturn) and shelling efficiency was 0.36, which was not significant.

[4] Correlation coefficient between milling quality (split-kernel outturn) and shelling rate was 0.22, which was not significant.

TABLE 2.—*Performance of cast-iron sheller with mixed varieties of runner, Spanish, and Virginia peanuts*[1]

Size of sheller bars and peanuts shelled	Major varieties in mixture	Slot size, 1st-stage sheller (1/64-inch)	No. lots tested	Average split-kernel outturn, full sheller[2] (pct)	Average shelling efficiency, 1st-stage sheller[2] (pct)	Average shelling rate 1st-stage sheller[2] (lb/hour)
2-inch-wide bars:[3]						
Runner	'Early Runner'	26	3	12.5a	64.6b	4,121ab
Spanish	'Starr' and 'Argentine'.	24	4	13.7a	78.7a	3,898a
Virginia	'Florigiant'	36	3	12.2a	63.6b	4,674b
4-inch-wide bars:[3]						
Runner	'Early Runner'	26	3	9.2a	66.3b	2,773a
Spanish	'Starr' and 'Argentine'.	24	4	10.8a	73.9a	3,400b
Virginia	'Florigiant'	36	3	12.5a	67.6b	4,478c

[1] Standard surge hopper and grate designs, 0.75 inch between cylinder and grate, and cylinder speed of 205 r/min were used for all runs. Grate sizes for 2d, 3d, and 4th stages of shelling selected to obtain a minimum split-kernel outturn (see table 1).

[2] Means not followed by the same letters are significantly different at the 0.05 level.

[3] Comparisons should not be made between data for the 2-inch-wide bars and data for the 4-inch-wide bars because test lots were not always the same.

steel-bar grate in this sheller. Of particular interest has been the wedge-slotted or T-bar grate, which has more than twice as much open area as does the cast-iron grate. Use of the T-bar grate in other shellers has shown that it must be sharpened frequently to insure good sheller performance and that the thickness of the T-bars tends to promote accumulation of foreign material, requiring more frequent plant shutdowns to unclog the shellers than with the cast-iron grate.

T-bar grate sections were designed for the cast-iron sheller (fig. 5). Some data comparing the performance of the cast-iron grate and steel T-bar grate (70 percent open area) are presented in table 3. There was no significant difference in split-kernel outturns for the two grates when shelling Spanish peanuts or (except for lot V1967SE1) when using the 4-inch-wide sheller bars. When using the narrower bars (2-inch and ½-inch) for shelling runner and Virginia peanuts, split kernel outturn for the T-bar grate was significantly lower than for the cast-iron grate.

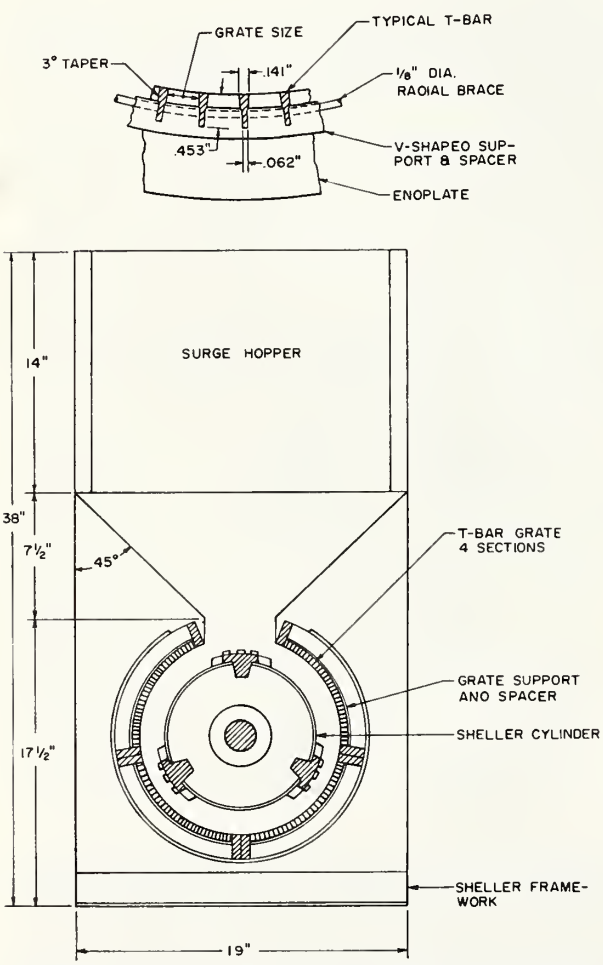

FIGURE 5.—Sectional sketch and details of steel T-bar grate. (*Top*) Details of grate. (*Bottom*) Sheller with grate installed.

Shelling efficiencies were usually higher with the T-bar grate than with the cast-iron grate. Because of the higher percentage of open area with the T-bar grate, optimum setups often required smaller grate sizes for the T-bar grate than for the cast-iron grate. In such setups, the T-bar grate provided shelling efficiencies 16 to 25 percentage points higher than the cast-iron grate.

For setups using approximately the same grate size, the shelling rates were significantly higher with the T-bar grate than with the cast-iron grate. However, when grate size of the T-bar grate was considerably less than that of the cast-iron grate, the shelling rate was usually higher with the cast-iron grate than with the T-bar grate.

Several combinations of T-bar and cast-iron grates were tried in the same sheller setup. The best combination was two T-bar and two cast-iron sections with the T-bar grate sections in the first and second positions, where most of the shelling occurs. However, except for possible wear and sheller maintenance considerations, even the best combination had no real advantage in performance over the T-bar grate, as indicated by the data for lot S1970SE.

Grate Arrangement, Surge Hopper Design, and Peanut Flow

The standard grate arrangement, surge hopper design, and method of directing peanuts into the sheller provide for a 4-inch-wide feed opening, and a 0- to 1.5-foot-high column of peanuts over the feed opening. The previously cited work by Reed and Coppoch on the small sheller indicated that wider feed openings, different grate arrangements, and different methods of directing peanuts into the sheller would improve sheller performance.

Several grate arrangements and surge hopper designs were devised with special emphasis on improving the flow of peanuts into the sheller. Grate arrangement was usually varied by removing a section of grate and shifting the positions of the remaining three sections. Variation in surge hopper designs usually consisted of

changing the design of deflectors to provide wider feed openings and better control of the direction of peanut flow. A 3- by 5-foot bin was constructed and installed over the sheller to provide a column of peanuts falling into the feed opening over its entire length. Some of the most successful arrangements, designs, and methods used are shown in figures 6 and 7. Performance data are presented in table 4 for the 4-inch-wide sheller bars and in table 5 for the 2-inch-wide sheller bars.

When using the 4-inch-wide cylinder bars,

TABLE 3.—*Effect of grate design on performance of cast-iron sheller*[1]

Peanuts shelled, lot number,[2] and grate used in 1st-stage sheller	Slot size, 1st-stage sheller (1/64-inch)	Width of sheller bars (inches)	Cylinder speed (r/min)	No. test samples	Average split-kernel outturn, full sheller[3] (pct)	Average shelling efficiency 1st-stage sheller[3] (pct)	Average shelling rate 1st stage sheller[3] (lb/hour)
Runner:							
R1965SE:							
Cast-iron	26	4	205	6	8.5a	([4])	([4])
T-bar	26	4	205	7	9.5a	([4])	([4])
R1966SE:							
Cast-iron	26	2	205	6	11.8a	64.9a	4,370a
T-bar	26	2	205	5	9.8b	71.6b	5,584b
R1967SE:							
Cast-iron	26	4	205	5	14.0a	56.2a	2,217a
T-bar	26	4	205	5	15.0a	59.5a	4,898b
Spanish:							
S1965SW:							
Cast-iron	24	4	203	5	3.4a	([4])	([4])
T-bar	24	4	225	5	3.8a	([4])	([4])
S1966SE:							
Cast-iron	24	4	215	8	11.1a	72.1a	3,242a
T-bar	24	4	215	4	10.9a	78.2a	3,691b
S1967SW:							
Cast-iron	24	4	225	4	10.3a	79.9a	4,579a
T-bar	22	4	225	4	11.8a	96.4b	2,869b
S1970SE:							
Cast-iron	22	2	205	5	12.3a	88.3a	3,177a
T-bar	22	2	205	5	12.9ab	95.2b	4,271b
Combination of cast-iron and T-bar	22	2	205	5	13.6b	90.4c	3,631c
Virginia:							
V1966VC1:							
Cast-iron	28	4	205	5	11.0a	91.5a	3,792a
T-bar	28	4	205	5	10.4a	91.0a	5,215b
V1966VC2:							
Cast-iron	28	[5]1/2	205	5	7.4a	87.5a	3,291a
T-bar	28	[5]1/2	205	5	6.3b	87.9a	3,672b
V1967SE1:							
Cast-iron	36	4	205	5	15.6a	70.7a	4,527a
T-bar	28	4	205	5	12.2b	94.7b	4,113a

[1] Standard surge hopper and distance between sheller bars and sheller grate of 0.75 inch were used for all tests except 1.12 inches was used for lot S1970SE. Grate sizes for 2d, 3d, and 4th stages of shelling were selected to obtain a minimum split-kernel outturn (see table 1).

[2] See table 1 for milling quality and other standard performance data.

[3] Comparisons should not be made between 2 different lots. Means not followed by the same letters are significantly different at the 0.05 level.

[4] Data were not obtained.

[5] See fig. 7 for details of shelling cylinder that uses ½-inch-wide sheller bars.

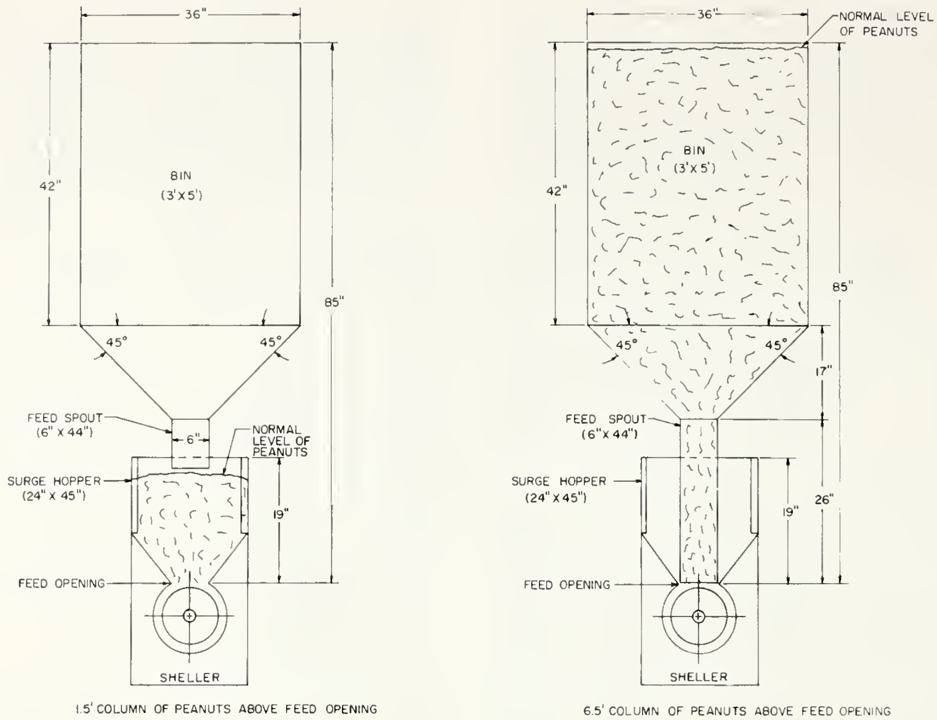

FIGURE 6.—Methods used to direct peanuts into the sheller.

TABLE 4.—*Effect of grate arrangement and surge hopper design on sheller performance when shelling lot R1970SE with 4-inch-wide sheller bars*[1]

Grate arrangement[2] and direction of peanut flow through feed opening	No. test samples	Surge hopper design[3]: Width of feed opening (inches)	Surge hopper design[3]: Column height (feet)	Average split-kernel outturn, full sheller[3] (pct)	Average shelling efficiency, 1st-stage sheller[3] (pct)	Average shelling rate, 1st-stage sheller[3] (lb/hour)
Standard; peanuts directed toward centerline of sheller	4	4	1.5	9.7a	75.0a	2,896a
Arrangement *A*; peanuts directed toward centerline of sheller	4	11	6.5	9.7a	79.2a	3,081a
Arrangement *B*; peanuts directed toward outside edge of shelling cylinder	4	11	1.5	10.0a	74.4a	2,897a
Do	2	11	6.5	11.4a	81.7a	5,488b

[1] Cast-iron grate, 1¼ inches between cylinder and grates, and cylinder speed of 205 r/min were used for all tests. Slot sizes for obtaining a minimum split-kernel outturn were 26/64 inch in the 1st stage of shelling, 23/64 inch in the 2d stage, 20.5/64 inch in the 3d stage, and 17/64 inch in the 4th stage.

[2] See figs. 5 and 6 for details of grate arrangement, surge hopper design, and methods of directing peanuts into sheller.

[3] Means not followed by the same letters are significantly different at the 0.05 level of significance.

none of the variables (grate arrangement, direction of peanut flow, width of feed opening, or column height) acting alone had any significant effect on sheller performance. However, all of the variables acting together to increase the flow of peanuts into the sheller provided a considerably higher shelling rate and a slightly (but not significantly) higher split-kernel outturn and shelling efficiency than obtained with the standard sheller setup.

A trend similar to that found for the setups using the 4-inch sheller bars was found for grate arrangements and surge hopper designs used with the 2-inch sheller bars. However, the 2-inch sheller bars did not restrict the flow of peanuts into the sheller as much as did the 4-inch sheller bars.

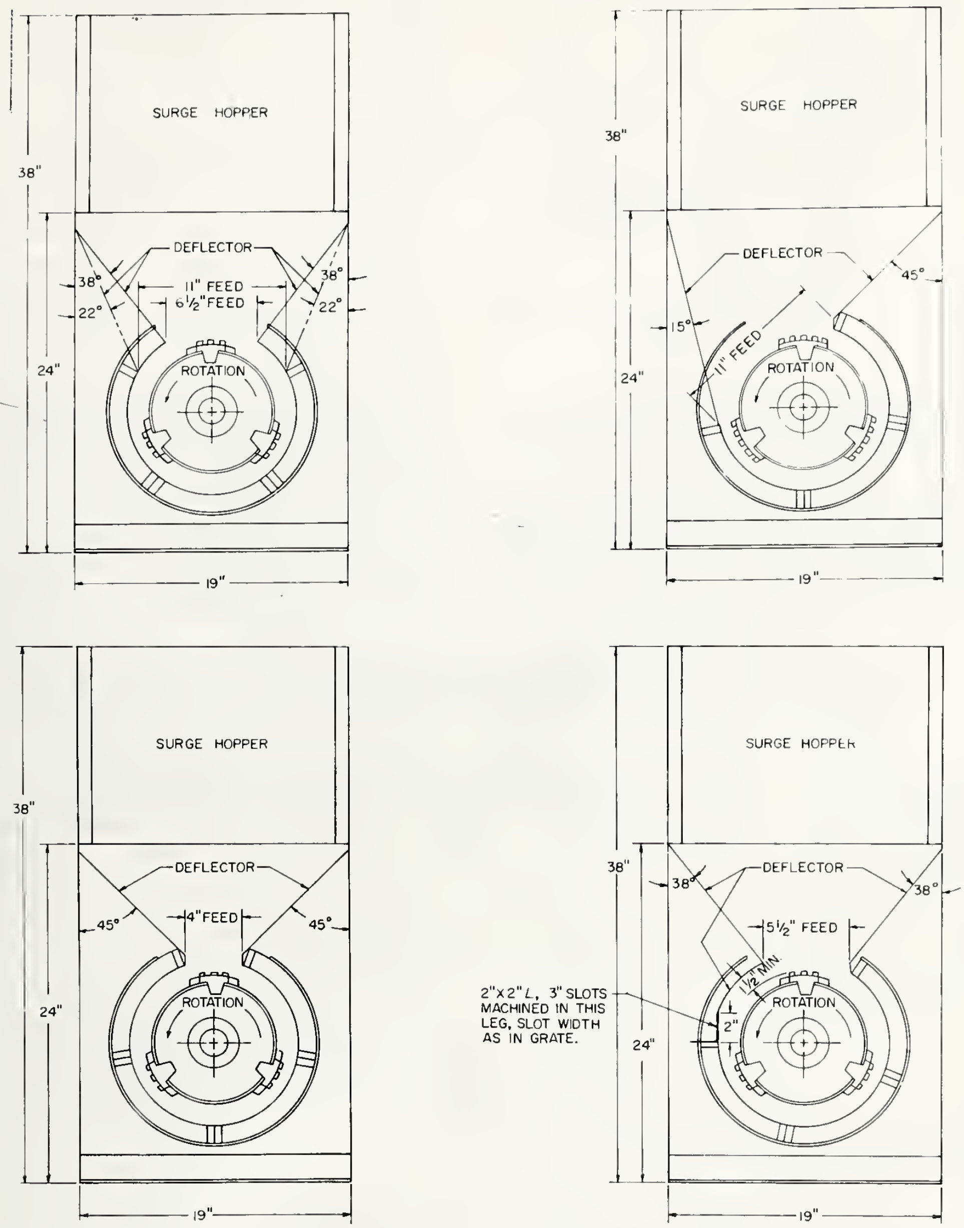

FIGURE 7.—Sectional views showing some grate configurations and surge hopper designs used with cast-iron sheller. (*Top left*) Arrangement *A*, three grate sections with center feed. (*Bottom left*) Standard, with four grate sections. (*Top right*) Arrangement *B*, three grate sections with off-center feed. (*Bottom right*) Arrangement *C*, three grate sections, with 2-inch angle-iron extension in modified U-shaped configuration.

With the 2-inch sheller bars each new grate arrangement, surge hopper design, and method used to increase the flow of peanuts into the sheller gave a significantly higher shelling rate and sometimes a significantly higher split-kernel outturn and shelling efficiency than did the standard setup. Except with the standard setup, a 6.5-foot-high column of peanuts above the feed opening resulted in excessively high split-kernel outturns. Grate arrangement *A* with an 11-inch-wide feed opening and only a 1.5-foot-high column of peanuts provided one of the highest shelling rates and had a considerably lower split-kernel outturn than did the setups using a 6.5-foot-high column of peanuts above the feed opening. Grate arrangement *C* with a 1.5-foot-high column of peanuts above the 5.5-inch-wide feed opening was one of the best arrangements because it provided a 34 percent higher shelling rate and about the same split-kernel outturns as did the standard setup.

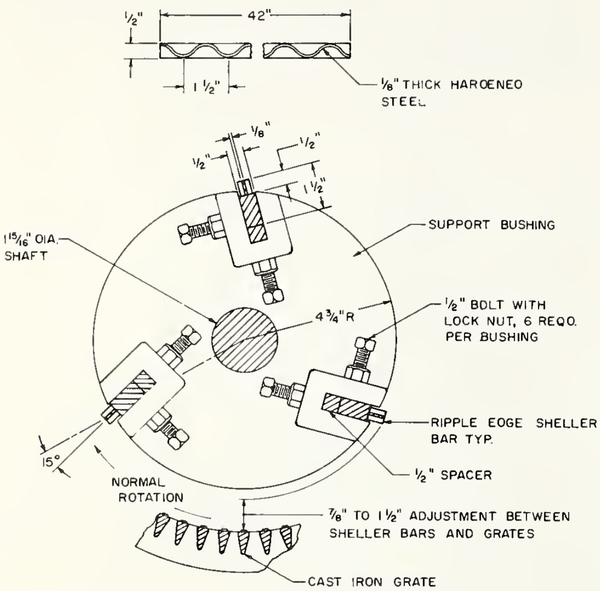

FIGURE 8.—Details of shelling cylinder with ripple-edged sheller bars. (*Top*) Shelling surfaces of ripple-edged sheller bars. (*Bottom*) Sectional view of cylinder and portion of grate.

Some of the new grate arrangements and surge hopper designs provided significantly higher shelling efficiencies than those obtained with standard designs and setups. However, the effects of grate arrangement and surge hopper design on shelling efficiency were minor in comparison with their effects on split-kernel outturn and shelling rate.

Sheller Bars and Cylinder Design

The cast-iron sheller normally includes an

TABLE 5.—*Effect of grate arrangement and surge hopper design on sheller performance when shelling Spanish peanuts (lot S1971SW) with 2-inch-wide sheller bars*[1]

Grate arrangement[2] and direction of peanut flow through feed opening	No. test samples	Surge hopper design[3]: Width of feed opening (inches)	Surge hopper design[3]: Column height (feet)	Average split-kernel outturn, full sheller[3] (pct)	Average shelling efficiency, 1st-stage sheller[3] (pct)	Average shelling rate, 1st-stage sheller[3] (lb/hour)
Standard; peanuts directed toward centerline of sheller	4	4	1.5	17.6a	91.6bc	3,182a
Do	4	4	6.5	19.9d	91.1ab	3,792b
Arrangement *A*; peanuts directed toward centerline of sheller	4	6.5	1.5	18.8bc	91.1ab	4,018bc
Do	4	6.5	6.5	25.8f	93.0de	4,463de
Do	2	11	1.5	19.4cd	92.3cd	4,708ef
Do	2	11	6.5	25.2ef	94.0e	5,052f
Arrangement *C*; peanuts directed toward centerline of sheller	4	5.5	1.5	17.9ab	90.6a	4,263cd
Do	4	5.5	6.5	24.3e	91.0ab	4,763f

[1] Cast-iron grate, 1⅛ inches between cylinder and grate, and cylinder speed of 205 r/min were used for all tests. Grate sizes were 22/64 inch in the 1st stage of shelling, 20.5/64 inch in the 2d stage, 19/64 inch in the 3d stage, and 15/64 inch in the 4th stage.

[2] See fig. 6 for details of grate arrangement and surge hopper design.

[3] Means not followed by the same letters are significantly different at the 0.05 level of significance.

TABLE 6.—*Comparison of sheller performance for the 2- and 4-inch-wide sheller bars*[1]

Lot number	Slot size, 1st-stage sheller (1/64-inch)	Samples shelled with—		Average split-kernel outturn, full sheller[2] (pct)		Average shelling efficiency, 1st-stage sheller[3] (pct)		Average shelling rate, 1st-stage sheller[4] (lb/hour)	
		2-inch sheller bars	4-inch sheller bars	2-inch sheller bars	4-inch sheller bars	2-inch sheller bars	4-inch sheller bars	2-inch sheller bars	4-inch sheller bars
R1966SE	26	6	3	11.8	10.9	64.9	59.3	4,525	3,379
R1967SE	26	3	5	14.4	14.0	63.6	56.2	3,416	2,217
S1966SW	24	5	3	4.8	4.1	69.4	68.6	3,066	2,903
S1967SW	24	5	3	10.4	9.9	78.6	79.1	4,698	4,330
V1966VC1	28	5	5	13.2	11.0	92.1	91.5	4,698	3,752
V1967SE	36	5	5	12.5	15.6	62.6	61.1	4,809	4,527

[1] Standard surge hopper, standard grate, distance of 0.75 inch between cylinder and grate, and cylinder speed of 205 r/min were used for all runs. Grate sizes for 2d, 3d, and 4th stages of shelling were selected to obtain a maximum whole-kernel outturn. See table 1 for other standard performance data.

[2] Split-kernel outturn for the 2- and 4-inch sheller bars was significantly different at the 0.05 level for lots V1966VC1 and V1967SE1.

[3] Shelling efficiencies for the 2- and 4-inch sheller bars were significantly different at the 0.05 level for lots R1966SE and R1967SE.

[4] Shelling rates for the 2- and 4-inch sheller bars were significantly different at the 0.05 level for lots R1966SE, R1967SE, and V1966VC1.

open cylinder with three 2- or 4-inch-wide cast-iron sheller bars equally spaced around the outside of the cylinder (see fig. 2). A few tests were conducted with a shelling cylinder that had ½-inch-wide ripple-edged steel bars to determine the potential of such an arrangement for improving sheller performance. The details of this cylinder are shown in figure 8.

A two-way analysis of variance examining six lots of peanuts and two sheller-bar widths was performed for split-kernel outturn, shelling efficiency, and shelling rate (table 6). There were significant differences in each characteristic, and interaction was found between lots and bar widths.

Differences in split-kernel outturn with the 2- and 4-inch sheller bars were small, as were the differences in shelling efficiency or shelling rate for the Spanish peanuts. Except for one lot of Virginia peanuts shelled with the grate having larger slots, the average split-kernel outturn was slightly higher with the 2-inch sheller bars than with the 4-inch sheller bars.

The 2-inch-wide sheller bars usually produced higher average shelling efficiencies and shelling rates than the 4-inch-wide sheller bars. The differences in the average shelling efficiencies and rates for the two bar widths were greater for runner and Virginia peanuts than for Spanish peanuts because the 4-inch-wide bars restricted the flow of the larger Virginia and runner peanuts more than they did the flow of the smaller Spanish peanuts.

Data comparing the two cylinder designs are in table 7. There were no significant differences

TABLE 7.—*Sheller performance with different shelling cylinders, using Virginia peanuts, lot V1966VC1*[1]

Cylinder design[2]	Average split kernel outturn, full sheller[3] (pct)	Average shelling efficiency, 1st-stage sheller[3] (pct)	Average shelling rate, 1st-stage sheller[3] (lb/hour)
Standard cylinder, 2-inch-wide sheller bars	13.2	92.1	4,698
Cylinder with ½-inch-wide, ripple-edged sheller bars	11.9	91.2	4,317

[1] Standard surge hopper, standard grate, distance of 0.75 inch between cylinder and grate, and cylinder speed of 205 r/min were used for all runs. 5 shelling tests were made with each cylinder.

[2] Slot sizes were 28/64 inch in the 1st stage of shelling, 26/64 inch in the 2d stage, 24/64 inch in the 3d stage, and 20.5/64 inch in the 4th stage.

[3] Values for the cylinder with the ripple-edged sheller bars were not significantly different from the values for the standard cylinder.

in sheller performance for the two types of cylinders. Thus, there were no apparent advantages in using the ripple-edged bar cylinder in lieu of the standard cast-iron cylinder.

Radial Distance Between Grate and Cylinder

Adjustment of the radial distance between the bars and grates of the standard sheller was limited to a range of zero to seven-eighths inch, so the bushings on the central shaft of the first-stage sheller were modified to allow evaluation of the cast-iron sheller bars at radial distances of zero to 1¼ inches. Generally, split-kernel outturn was excessive when the radial distance was less than three-fourths inch. Data were obtained primarily with spacings of three-fourths to 1¼ inches.

The effects of distance between cylinder and grate on sheller performance are illustrated by figure 9. There was a highly significant effect (0.01 level of significance) of distance between cylinder and grate on the split-kernel outturn, shelling rate, and shelling efficiency. The optimum setting for obtaining a maximum whole-kernel outturn was 1.107 inch, but differences in split-kernel outturn were very small for settings of 1 to 1¼ inches. Limited studies with runner and Virginia peanuts indicate that the optimum setting in the first-stage sheller for obtaining maximum whole-kernel outturn is slightly larger (range of 1⅛ to $1\frac{5}{16}$ inches) than the optimum setting for Spanish peanuts and is related to the pod size. Thus, optimum settings for later stages of shelling would be slightly smaller than for the first stage. Shelling rate and efficiency increased substantially as

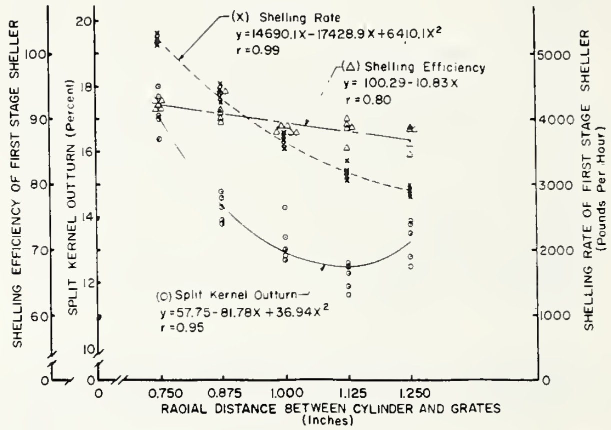

FIGURE 9.—Effect of distance between cylinder and grate on sheller performance with Spanish peanuts lot S1970SE).

TABLE 8.—*Effect of grate slot size on performance of cast-iron sheller*[1]

Peanuts shelled and lot number	Slot size ($\frac{1}{64}$-inch) in— 1st stage	2d stage	3d stage	4th stage	Width of sheller bars (inches)	No. test samples	Average split-kernel outturn, full sheller[2] (pct)	Average shelling efficiency, 1st-stage sheller[2] (pct)	Average shelling rate 1st-stage sheller[2] (lb/hour)
Runner:									
R1965SE	26	23	20.5	15	4	6	8.5a	([3])	([3])
R1965SE	28	24	20.5	15	4	6	9.3a	([3])	([3])
R1966SE	24	23	20.5	15	2	5	12.0a	78.2a	3,670a
R1966SE	26	24	20.5	15	2	6	11.8a	64.9b	4,525b
R1966SE	28	24	20.5	15	2	6	10.6b	53.6c	4,415ab
Spanish:									
S1966SW	22	20.5	19	15	2	5	4.6a	85.7a	3,302a
S1966SW	24	23	20.5	15	2	5	4.8a	69.4b	3,066a
Virginia:									
V1967SE1	30	28	26	19	2	5	11.8a	88.8a	4,408a
V1967SE1	36	28	26	19	2	5	12.8a	63.4b	5,100a
V1967SE2	30	28	26	19	4	5	8.8a	91.3a	3,986a
V1967SE2	36	28	26	19	4	5	7.7b	70.0b	4,985b

[1] Standard grate and surge hopper, 0.75 inch between cylinder and grate, and sheller speed of 205 r/min were used on all runs. See table 1 for milling quality and standard performance information.

[2] Comparisons should not be made between 2 different lots. Means in the same lot not followed by the same letters are significantly different at the 0.05 level.

[3] Data were not obtained.

the spacing between cylinder and grate was decreased from $1\frac{1}{4}$ inches to three-fourths inch. Spacings larger than seven-eighths inch are seldom used by industry because they frequently result in clogging of the sheller grate and shellers by foreign material. Evidently, the smaller clearance between grate and cylinder breaks up some of the foreign material so it can pass through the slots and be removed by aspiration or other plant operations. The closer spacings also balance some of the loss in shelling rate from wear of the sheller bars and grates.

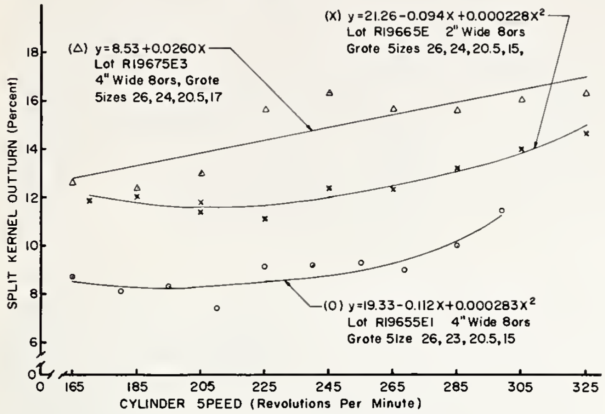

FIGURE 10.—Effect of cylinder speed on split-kernel outturn for runner peanuts.

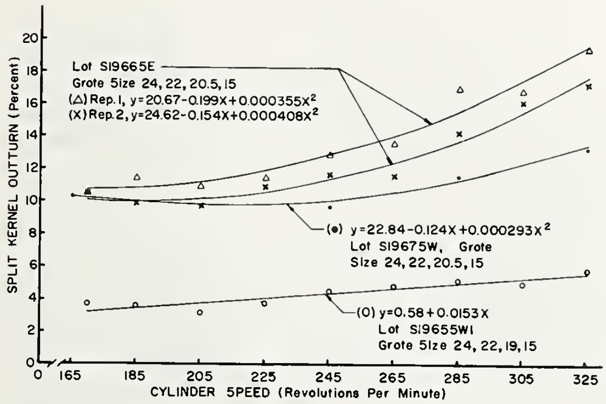

FIGURE 11.—Effect of cylinder speed on split-kernel outturn for Spanish peanuts, using 4-inch-wide sheller bars.

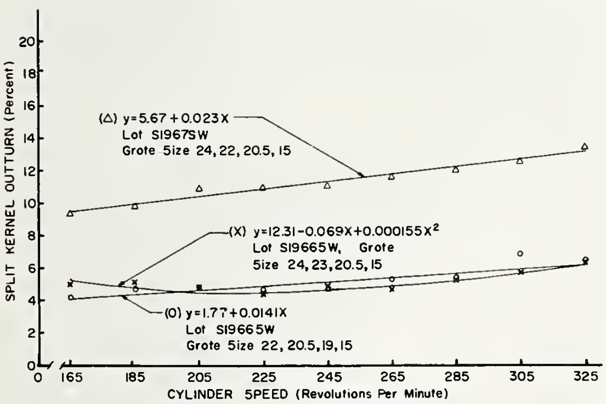

FIGURE 12.—Effect of cylinder speed on split-kernel outturn for Spanish peanuts, using 2-inch-wide sheller bars.

Grate Slot Size

Many different combinations of grate slot sizes were evaluated for each type of peanut. Average data for the best combinations found for shelling peanuts having the normal range of pod and kernel sizes are presented in table 8. Generally, slot combinations with sizes smaller than those listed resulted in excessive splitting of kernels and combinations with sizes

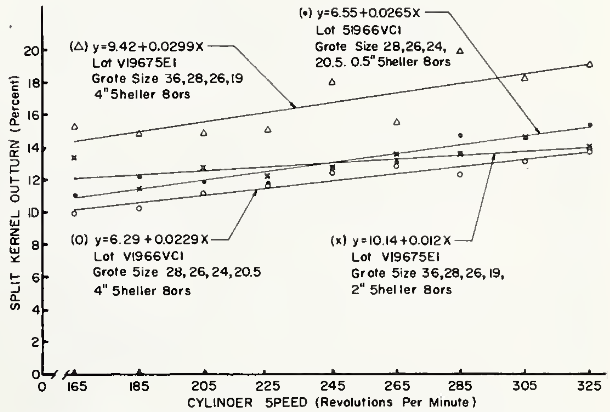

FIGURE 13.—Effect of cylinder speed on split-kernel outturn for Virginia peanuts.

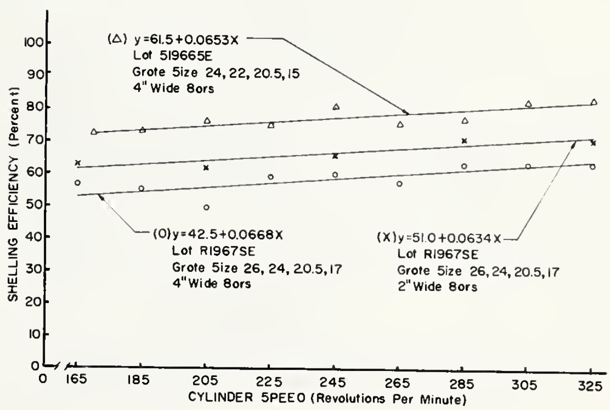

FIGURE 14.—Effect of cylinder speed on shelling efficiency for runner and Spanish peanuts.

larger than those listed resulted in poor shelling efficiencies.

Generally, the effect of grate size on split-kernel outturn was small (0 to 1.4 percentage points) as long as the slot was large enough to allow the whole kernels to escape. However, the effect of grate size on shelling efficiency was large (11 to 25 percentage points) and combinations with the smallest slots always provided the highest shelling efficiencies. The sheller essentially shelled all of the pods that were 2/64 inch larger than the slot. The effect of grate size on shelling rate was significant only for the runner and Virginia peanuts. For these large peanuts, combinations with the smallest slots usually gave the lowest shelling rates (14 to 20 percent reductions).

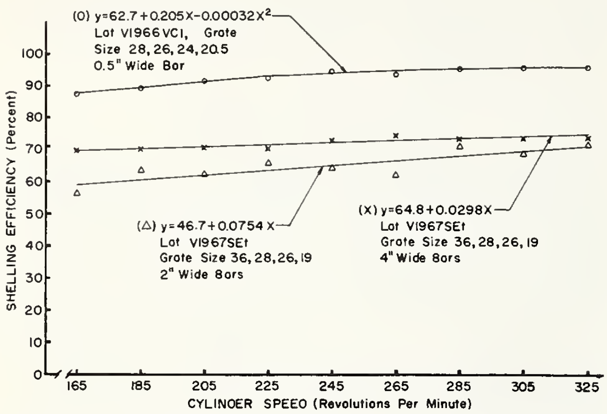

FIGURE 15.—Effect of cylinder speed on shelling efficiency for Virginia peanuts.

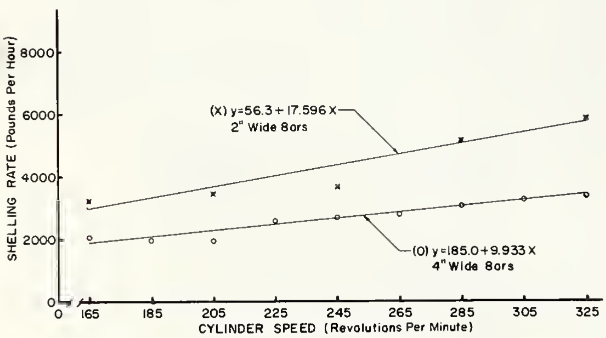

FIGURE 16.—Effect of cylinder speed on shelling rate for lot R1967SE.

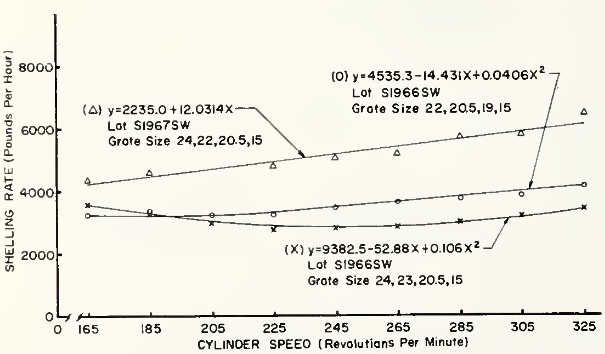

FIGURE 17.—Effect of cylinder speed on shelling rate for Spanish peanuts, using 2-inch-wide sheller bars.

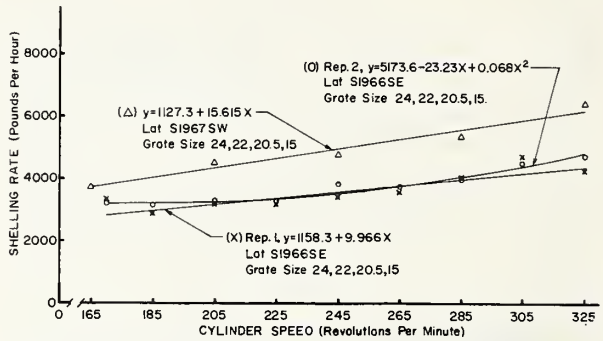

FIGURE 18.—Effect of cylinder speed on shelling rate for Spanish peanuts, using 4-inch-wide sheller bars.

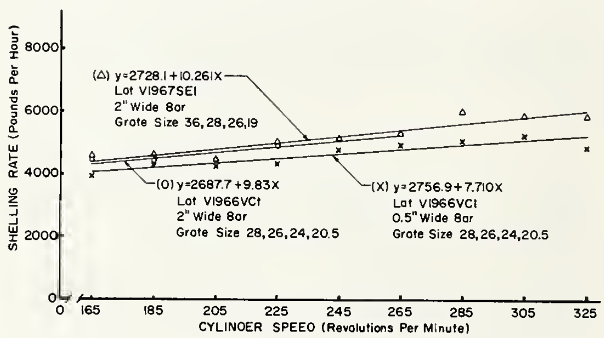

FIGURE 19.—Effect of cylinder speed on shelling rate for Virginia peanuts, using 0.5- and 2-inch-wide sheller bars.

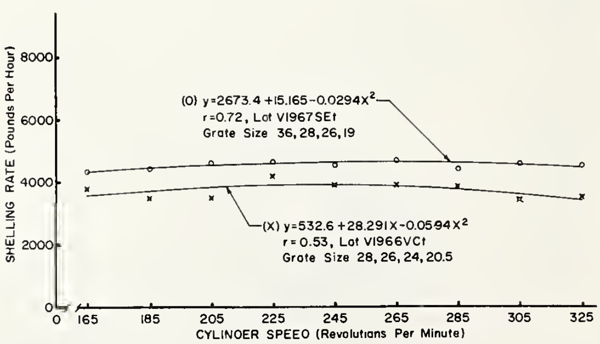

FIGURE 20.—Effect of cylinder speed on shelling rate for Virginia peanuts, using 4-inch-wide sheller bars.

Cylinder Speed

The effect of cylinder speed on sheller performance was determined by shelling samples at cylinder speeds in the range of 165 to 325 revolutions per minute (r/min). Regression equations, correlation coefficients, and significance of regressions are presented in table 9. Regressions that were statistically significant at the 0.05 level are shown in figures 10 through 20.

Although some of the regressions were not significant at the 0.05 level, an analysis of covariance for each lot confirmed that cylinder speed had a significant effect on sheller performance for each lot. Significant regressions showed that split-kernel outturn, shelling efficiency, and shelling rate generally increased as cylinder speed was increased. Most of the significant regressions were linear in the form of $Y=c+bX$, but some were quadratic of the form $Y=aX^2-bX+c$ (parabola), where Y is the split-kernel outturn, shelling efficiency, or shelling rate; X is sheller speed in revolutions per minute; a and b are regression coefficients; and c is a constant (Y-intercept). The average slope (b) or average rate of increase for the significant linear regressions of split-kernel outturn was 0.021 percentage points per r/min; for shelling efficiency, b was 0.06 percentage points per r/min; and for shelling rate, b was 11.6 lb/h per r/min. Significant quadratic relationships for split-kernel outturn and cylinder speed were obtained for only Spanish and runner peanuts. Significant quadratic regressions for cylinder speed and shelling rate were found only for Spanish peanuts.

The significant quadratic relationships usually showed a slight decrease in split-kernel outturn or shelling rate as the cylinder speed was increased from 165 r/min to a speed where the split-kernel outturn or shelling rate reached its minimum. Differentiating these quadratic equations and setting the slope equal to 0 showed that speeds of 168 to 223 r/min gave a minimum split-kernel outturn and speeds of 171 to 245 r/min gave a minimum shelling rate. From these minimum points to 325 r/min, the significant quadratic regressions showed a slope that increased from 0 to an average of 0.07 percentage points per r/min for the split-kernel relationships and from 0 to an average of 16.3 lb/h per r/min for shelling rate relationships.

Interactions of cylinder speed with other variables had significant effects on split-kernel outturn and shelling rate. However, peanut quality and types, width of sheller bars, and grate size seldom influenced the effect of cylinder speed on shelling efficiency. The effect of cylinder speed on split-kernel outturn was generally more for peanuts of poor milling quality than for peanuts of good milling quality (see fig. 21) as shown by almost twice as much an increase in split-kernel outturn resulting from an increase in sheller speed for the peanuts with the poorest milling quality over the outturn for those with the best milling quality.

The effect of cylinder speed on shelling rate varied with each lot of peanuts, but there was no consistent influence of milling quality on the way cylinder speed affected shelling rate.

Interactions of cylinder speed with peanut types were indicated by the different regression equations calculated for each type as discussed previously. There was further evidence that interactions of cylinder speed, type of peanuts, and width of sheller bars affected the shelling rate. Significant interactions of cylinder speed and width of sheller bars were found for four of five lots. Generally, cylinder speed affected the shelling rate of the 2-inch-wide sheller bars more than for the 4-inch-wide sheller bars. (See fig. 16, and compare the curves of fig. 17 with the curves of fig. 20.) For the 2-inch sheller bars, the effect of cylinder speed on shelling rate was approximately the same for each type of peanut. However, the effect of cylinder speed on shelling rate for the 4-inch sheller bars was

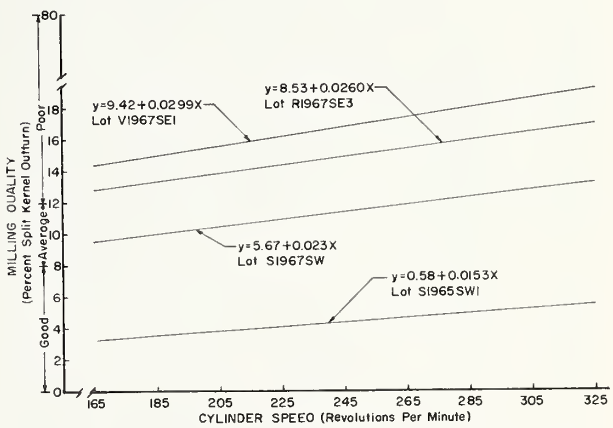

FIGURE 21.—Effect of sheller speed on split-kernel outturn for peanuts having good, average, or poor milling quality.

TABLE 9.—*Regression equations, correlation coefficients, and significance of regressions describing effects of cylinder speed on sheller performance*[1]

Peanuts shelled and lot number	No. test samples	Width of sheller bars (inches)	Slot size (1/64-inch) in— 1st stage	2d stage	3d stage	4th stage	Split-kernel outturn[2] (Y) Regression equation	Correlation coefficient	Level of significance[5] (pct)	Shelling efficiency[3] (Y) Regression equation	Correlation coefficient	Level of significance[5] (pct)	Shelling rate[4] (Y) Regression equation	Correlation coefficient	Level of significance[5] (pct)
Runner:															
R1965SE	10	4	26	23	20.5	15	$Y=19.33-0.112X+0.000283(X^2)$.	0.91	0.26**	...	...	...	...	...	...
R1965SE	10	4	28	24	20.5	15	$Y=-7.66+0.145X-0.000296(X^2)$.	.67	12.15	...	...	...	...	...	...
R1966SE	9	2	24	23	20.5	15	$Y=25.74-0.131X+0.000309(X^2)$.	.89	.91**	$Y=107.06-0.268X+0.000607(X^2)$.	0.71	16.80	$Y=3{,}156.7+2.754X$	0.68	13.94
R1966SE	10	2	26	24	20.5	15	$Y=21.26-0.094X+0.000228(X^2)$.	.97	.02**	$Y=131.86-0.583X+0.00121(X^2)$.	.83	5.60	$Y=12{,}084.1-66.26X+0.1378(X^2)$.	.88	10.30
R1966SE	10	2	28	24	20.5	15	$Y=9.54+0.00627X$	.32	36.60	$Y=309.56+4.642X-0.01927(X^2)+0.000026(X^3)$.	.47	71.70	$Y=3{,}887.4+2.919X$	.40	43.56
R1967SE	9	4	26	24	20.5	15	$Y=8.53+0.0260X$	.85	.35**	$Y=42.48+0.0668X$	.79	1.10*	$Y=185.0+9.933X$	.96	.01**
R1967SE	5	2	26	24	20.5	15	$Y=11.68+0.0139X$	.69	19.30	$Y=51.01+0.0634X$	.93	2.20*	$Y=-56.3+17.596X$	.94	1.70*
Spanish:															
S1965SW	9	4	24	22	19	15	$Y=0.58+0.0153X$	.92	.04**	...	...	...	...	...	...
S1966SE	9	4	24	22	19	15	$Y=20.67-0.119X+0.000355(X^2)$.	.98	.02**	$Y=61.50+0.0653X$	.87	.23**	$Y=5{,}173.6-23.23X+0.0680(X^2)$.	.98	.03**
S1966SE	9	4	24	22	19	15	$Y=24.62-0.154X+0.000408(X^2)$.	.98	.02**	$Y=630.7-6.992X+0.0282(X^2)-0.0000366(X^3)$.	.87	5.25	$Y=1{,}158.3+9.966X$	.86	.27**
S1966SW	5	4	24	23	20.5	15	$Y=33.51-0.362X+0.00143(X^2)-0.00000182(X^3)$.	.92	47.04	$Y=64.0+0.248X$	.68	20.96	$Y=2{,}098+4.000X$	.78	11.71
S1966SW	9	2	22	20.5	19	15	$Y=1.77+0.0141X$	.89	.12**	$Y=210.6-1.642X+0.007(X^2)-0.00000961(X^3)$.	.72	26.01	$Y=4{,}535.3-14.431X+0.0406X$.	.98	.04**
S1966SW	9	2	24	23	20.5	15	$Y=12.31-0.069X+0.000155(X^2)$.	.93	.36**	$Y=-170.7+3.149X-0.0135(X^2)+0.00001894(X^3)$.	.84	8.62	$Y=9{,}382.5-52.888X+0.1060(X^2)$.	.98	.04**
S1967SW	5	4	24	22	20.5	15	$Y=22.84-0.124X+0.00293(X^2)$.	.99	2.14**	$Y=72.7+0.0318X$	.75	14.23	$Y=1{,}127.3+15.615X$	.98	.44**
S1967SW	9	2	24	22	20.5	15	$Y=5.67+0.0230X$	.98	.01**	$Y=105.6-0.0239X+0.000514(X^2)$.	.63	21.23	$Y=2{,}235.0+12.031X$	.96	.02**
Virginia:															
V1966VC1	9	4	28	26	24	20.5	$Y=6.29+0.0229X$	.97	.01**	$Y=13.4+1.285X-0.0051(X^2)+0.00000672(X^3)$.	.78	16.51	$Y=532.6+28.291X-0.0594(X^2)$.	.53	37.21
V1966VC1	6	2	28	26	24	20.5	$Y=13.83-0.0027X$	.10	85.10	$Y=404.7-4.415X+0.0204(X^2)-0.0000307(X^3)$.	.98	6.71	$Y=2{,}687.7+9.830X$	.94	.46**
V1966VC1	9	.5	28	26	24	20.5	$Y=6.55+0.0265X$	.95	.01**	$Y=62.7+0.205X-0.000320(X^2)$.	.99	.01**	$Y=2{,}756.9+7.710X$	.90	.10**

V1967SE1	9	4	36	28	26	19	$Y=9.42+0.0299X$	.81	.80**	$Y=64.8+0.0298X$	.88	.20**	$Y=2{,}673.4+15.165X$ $-0.0294(X^2)$.	.72	11.05
V1967SE1	9	2	36	28	26	19	$Y=10.14+0.0120X$ ..	.68	4.22*	$Y=46.7+0.0754X$	.85	.33**	$Y=2{,}728.1+10.261X$.	.95	.01*

[1] Standard grate and surge hopper design were used on all runs. Distance between cylinder and grate was 0.750 inch on all runs.

[2] Significant interactions of cylinder speed and slot size were found for lots R1965SE and S1966SW. Significant interactions of cylinder speed and width of sheller bars were found for lots V1966VC1 and S1967SW.

[3] Significant interactions of cylinder speed and slot size were found for lot S1966SW. Significant interactions of cylinder speed and width of sheller bars were found for lot V1967SE1.

[4] Significant interactions of cylinder speed and slot size were found for lot S1966SW. Significant interactions of cylinder speed and width of sheller bars were found for lots R1967SE, S1966SW, V1966VC1, and V1967SE1.

[5] Regressions were significant at the indicated level. * Significant at the 0.05 level. ** Significant at the 0.01 level.

much larger for Spanish and runner peanuts than for Virginia peanuts (compare figs. 16, 18, and 20). Evidently, the 4-inch bars with the large peanuts restricted the flow of peanuts into the sheller, minimizing the effects of cylinder speed on shelling rate. It appeared that increasing the cylinder speed for the 4-inch bars beyond 265 r/min helped to obstruct the flow of the larger peanuts (fig. 20).

The effect of cylinder speed on split-kernel outturn appeared to be slightly different for each combination of slot sizes. Two of three lots showed significant interactions of cylinder speed with grate size. (Interaction for lot S1966SW is illustrated by fig. 12.) Generally, the effect of cylinder speed on split-kernel outturn was greater for the combination of slots that were approximately the same size as the largest kernels than for grate combinations with larger slots. The use of the latter combinations are impractical for most commercial shelling plants because of their poor shelling efficiencies (see table 8).

Shelling rate was affected by significant interaction of cylinder speed and grate size for lot S1966SW, as illustrated in fig. 17. This interaction indicates a larger increase in shelling rate with speed for the grate with the 22/64 inch slots than for the grate with the 24/64 inch slots.

DISCUSSION

The best possible performance was obtained with our pilot-plant sheller because the grate and sheller bars were new and the peanuts were essentially free of foreign material. In commercial shelling plants, poorer sheller performance should be expected because these ideal conditions cannot be completely maintained. The unusually high shelling rates reported here illustrate the potential improvements in sheller performance through efficient precleaning of the peanuts and good maintenance of the cast-iron sheller.

The split-kernel outturn (which is a measure of milling quality), shelling efficiency, and shelling rate varied considerably among lots. Some of these variations were undoubtedly related to the mixing of varieties while in storage and the inherent differences in the physical properties of the peanuts. Such variations are experienced in commercial shelling and make it

difficult to set up, monitor, and maintain shellers and shelling plants so that they give an optimum performance. It was quite evident from our results that these variations could be minimized by limiting each lot to a single variety grown in the same area so that the peanuts in one lot would have similar physical characteristics and would shell similarly. A recently developed experimental sample sheller[7] could be used to segregate lots and to prescribe sheller adjustments needed to shell peanuts from each lot.

The milling quality, type of peanuts, and size of pods and kernels usually determined the optimum combination of sheller bars, grate size, and cylinder speed.

The 4-inch-wide sheller bars provided a slightly lower split-kernel outturn and performed equally as well overall as the 2-inch-wide bars when shelling Spanish peanuts. However, when shelling the larger runner and Virginia peanuts, the 4-inch bars restricted the flow of these peanuts into the sheller more than the 2-inch bars, so sheller performance with the 2-inch bars was much better. Because the 4-inch bars offered greater restrictions to the peanut flow, the effects of the other variables on sheller porformance were usually not as much with the 4-inch bars as with the 2-inch bars. Thus, the 2-inch bars would allow more effective adjustment of these variables and a more versatile sheller operation.

Grate size was the primary variable controlling shelling efficiency as the cast-iron sheller shelled most of the pods that were larger than the grate size. The grate sizes that provided the best sheller performance were usually those that were about the same as or slightly larger than the largest kernels. For the larger peanuts that bring a premium price as whole kernels, it was very important that the grate size used minimized the splitting of these larger kernels. Use of grate sizes in a commercial sheller smaller than the largest kernels would generally result in excessively high split-kernel outturns, low shelling rates, and a tendency for such variables as cylinder speed to cause an additional increase in split-kernel outturn.

The option to change cylinder speeds results in a more versatile sheller and shelling plant operation than is possible without this option. The best cylinder speed for obtaining a minimum split-kernel outturn was in the range of 165 to 223 r/min. When selecting higher cylinder speeds, operators should carefully consider the effect on sheller performance of interactions of cylinder speed with milling quality, type of peanuts, width of sheller bars, and grate size. When shelling peanuts of good milling quality with the 2-inch bars and a grate slot large enough to pass the largest kernels, an increase in cylinder speed from the best speed to a maximum of 265 r/min will result in a substantial increase in shelling rate with a minimal effect on split-kernel outturn and shelling efficiency. However, selecting higher cylinder speeds to shell peanuts of poor milling quality or using higher speeds with smaller grate sizes than those recommended will result in higher split-kernel outturns that will normally offset any real benefits of higher shelling efficiencies and shelling rates. The general pattern shown by these interactions also applies to shelling Spanish and runner peanuts with the 4-inch bars. However, there is no substantial benefit from increasing cylinder speed when shelling Virginia peanuts with the 4-inch bars.

The standard grate arrangement, surge hopper, and sheller bars restricted the flow of peanuts into the sheller. These restrictions had very little effect on the split-kernel outturn and shelling efficiency but limited the shelling rate to nominal values. By lessening these obstructions to flow, the shelling rate of the cast-iron sheller was increased by 34 to 90 percent without any substantial change in split-kernel outturn and shelling efficiency. The most effective method found for increasing flow was to modify the standard grate arrangement and surge hopper to provide wider feed openings. A 6.5-foot-high column of peanuts above the feed opening and direction of the peanut flow tangential to the shelling cylinder were also required to overcome the resistance of the 4-inch bars. Because of excessive splitting of kernels, the tangential direction of feed or the 6.5-foot-high column of peanuts work best with the 4-inch bars; the 6.5-foot-high column of peanuts could be used to obtain a higher shelling rate at the expense of a nominal increase in split-kernel outturn for the standard sheller when using the 2-inch bars. Evidently, using

[7] Davidson, J. I., Jr., and McIntosh, F. P. 1973. Development of a small laboratory sheller for determining peanut milling quality. J. Am. Peanut Res. Educ. Assoc. Inc. 5(1): 95–108

sheller bars narrower than 2 inches would not result in any substantial improvements in sheller performance.

Even though the cast-iron grate performed well, the results of this study show that the grate design could be improved by providing additional openings to allow more kernels to escape and additional sharp edges for more efficient shelling action. The T-bar grate appears to be an excellent alternate to the cast-iron sheller, provided the initial and operating expenses of the T-bar grate are not prohibitive. The primary advantages of this grate are that it provides a very high shelling efficiency, a high shelling rate, and a nominal-to-low split-kernel outturn. The advantages were more evident when shelling runner and Virginia peanuts than when shelling Spanish peanuts. The T-bar grate performed best with the narrow ½- or 2-inch-wide sheller bars than with 4-inch-wide bars. The primary disadvantage of this grate is that the thin T-bars become worn and require frequent sharpening to maintain their performance. The width of the T-bars also provides a rather deep slot that tends to prevent irregularly shaped foreign material from passing through the grate opening, and apparently shellers with T-bar grates accumulate more foreign material than shellers with the shallow-slotted, cast-iron grates. Use of simple grinding fixtures to sharpen the grates, use of efficient methods and equipment for precleaning the peanuts, and development of shelling cylinders to provide automatic cleanout would minimize the maintenance required for the T-bar grate.

Modification of the standard shelling cylinder to allow larger spacings between the cylinder and grate would considerably reduce the split-kernel outturns of the cast-iron sheller and would provide a more versatile operation. The optimum spacings for a minimum split-kernel outturn would probably be 1 inch to 1⅜ inches for the first-stage sheller and ¾ to 1 inch for the later stages of shelling. The actual setting selected would depend upon the size of the pods being shelled. More efficient precleaning and modification of the shelling cylinder to allow automatic cleanout of the sheller would minimize buildup of foreign material in the sheller when using the larger settings.

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